CITY OF LINCOLN, NEBRASKA, STANDARD SPECIFICATIONS

Chapter 11

PORTLAND CEMENT CONCRETE

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PORTLAND CEMENT CONCRETE

11.00 GENERAL

Portland Cement Concrete shall consist of an intimate mixture of Portland Cement, aggregate, water and an air-entraining admixture. Depending on the application, other constituents or admixtures may be used with permission from the Engineer. Materials not on the latest edition of the Nebraska Department of Roads "Approved Products List" shall not be used without permission from the Engineer. The constituents of Portland Cement Concrete and their mixing, handling, and proportioning shall conform to ASTM Designation C 94 except as modified herein.

11.01 MATERIALS

A. CEMENT

Portland Cement shall be a recognized standard hydraulic cement composed primarily of hydraulic calcium silicates conforming to the requirements of ASTM Designation C 150 for Type I, II, or III cement and shall contain no more than 0.60 percent equivalent alkali. Equivalent alkali is defined as the sum of the sodium oxide (Na_2O) and the potassium oxide (K_2O) calculated as sodium oxide (equivalent alkali as $Na_2O = Na_2O + 0.658(K_2O)$). Certified mill tests shall be furnished to the Engineer. Different brands of cement, or the same brand from different mills, shall not be mixed during storage. Neither shall they be used alternately in any one concrete placement without permission from the Engineer. Contractors or subcontractors supplying concrete shall notify the Engineer when changing to a different cement.

The cement shall be protected from damage due to moisture. Cement so damaged will be rejected. Cement shall not be in storage longer than ninety (90) days without retesting. The temperature of the cement when used shall be less than 180°F.

B. AGGREGATE

1. General

Only aggregates that have been approved by the Nebraska Department of Roads and used for similar work and have satisfactory service records will be approved.

Mineral aggregates shall be crushed rock, broken stone, gravel, sand-gravel, coarse sand, fine sand, or a mixture of these materials composed of clean, hard, durable, and un-coated particles. Crushed rock shall be crushed limestone, dolomite, granite, quartzite, or other ledge rock.

Dolomite as herein defined is a magnesium limestone containing calcium carbonate and magnesium carbonate in approximately a 4 to 3 ratio.

The calcium carbonate content of limestone shall be at least 80 percent computed as CaCO3 from the value determined for CaO.

B. AGGREGATE (Continued)

1. General (Continued)

Aggregates shall be free from injurious quantities of dust, soft or flaky particles, loams, alkali, organic matter, paper, wood, or other deleterious matter as determined by the Engineer.

The use of aggregate obtained from any reclaiming or recycling process shall not be allowed without permission from the Engineer.

The gradations shown for the aggregate represent limits which shall determine suitability for use from any source of supply. The gradations from any one source shall be uniform and not subject to the extreme percentages of gradation specified below. The aggregate from different sources of supply shall not be mixed or stored in the same pile, nor used alternately in the same class of construction or mixed without permission from the Engineer. The aggregate may be tested at any time prior to its incorporation into a mix. Aggregate sampling and testing shall conform to the following requirements:

ASTM DESIGNATIONS

C 33	Specification for Concrete Aggregates

AASHTO DESIGNATIONS

T 96	Abrasion
T 104	Sodium Sulfate Soundness
T 21	Organic Impurities
T 71	Mortar-Making Properties

NEBRASKA DEPARTMENT OF ROADS

NDR T 2	Sampling
NDR T 27	Sieve Analysis
NDR T 504	Clay Lumps, Shale, and Soft Particles
NDR T 103	Freeze and Thaw Soundness
NDR T 85	Specific Gravity and Absorption (Coarse Aggregate)
NDR T 84	Specific Gravity and Absorption (Fine Aggregate)
NDR T 89	Determining The Liquid Limit of Soils
NDR T 90	Determining The Plastic Limit and Plasticity Index of Soils
NDR T 5	Calcium Carbonate
NDR T 248	Reducing Field Samples of Aggregate to Testing Size

Fine sand shall have at least 95 percent of its particles pass the No. 10 sieve and no more than 25 percent pass the No. 200 sieve. This definition applies to the sodium sulfate soundness test.

B. AGGREGATE (Continued)

1. General (Continued)

Once an aggregate's soundness and abrasion quality has been determined, additional quality testing for soundness and abrasion loss will be at the Engineer's discretion.

Aggregate shall be evaluated based upon its past performance in concrete pavement and in laboratory test results. Aggregate with adversely reactive constituents shall not be used.

During the progress of the work, should the quality of the aggregate appear to change appreciably, the Contractor may be required to furnish satisfactory evidence of its soundness. The Engineer may, from time to time during the progress of the work, make check tests of the gradation of the aggregates. Any materials failing to meet the requirements of the Specifications shall be rejected and removed from the site of the work.

Aggregates shall meet the gradation requirements of Table 11.01, for the Class of Concrete shown in Table 11.02, of these specifications. For all other applications such as overlay concrete or mortar and grout sands, the gradation requirements in Section 1033, "Aggregates", of the latest version of the Nebraska Department of Roads "Standard Specifications for Highway Construction" shall apply.

2. Fine Aggregate

Fine aggregate shall consist of sand or sand-gravel or a combination of sand and sand-gravel. The sand and sand-gravel shall be washed and composed of clean, hard, durable and un-coated particles. Aggregates produced from wet pits by pumping will be considered to be washed. Aggregates from a dry pit shall have the method for washing approved by the Engineer. The fine aggregate shall be free from injurious amounts of clay, loam, alkali, organic matter and other deleterious substances.

Fine aggregate shall have a soundness loss of not more than 10 percent by weight at the end of 5 cycles using sodium sulfate solution.

The aggregate shall contain no more than one-half percent (0.5%) by weight of clay lumps.

The aggregate which produces a color darker than the standard color when subjected to the colorimetric test for organic impurities shall be tested for its mortar-making properties in accordance with AASHTO T 71.

The aggregate, when subjected to the mortar-making properties test, shall produce a mortar having a compressive strength at the age of 7 days equal to or greater than that developed by mortar of the same proportions and consistency made of the same cement and aggregate after the aggregate has been treated in a 3 percent solution of sodium hydroxide. Materials failing to produce equal or greater strength shall not be accepted, without permission from the Engineer.

11.01 MATERIALS (Continued)

B. AGGREGATE (Continued)

3. Coarse Aggregate

Coarse aggregate shall consist of limestone composed of clean, hard, durable, and uncoated particles. These materials are natural sedimentary rock composed principally of calcium carbonate.

The calcium carbonate content of the aggregate shall be at least eighty percent (80%) (computed as $CaCO_3$ from value determined for CaO).

The percent of clay lumps, shale, or soft particles shall not exceed the following amounts:

Clay Lumps	0.5 percent
Shale	1.0 percent
Soft Particles	3.5 percent

Any combination of clay lumps, shale and soft particles shall not exceed three and one-half percent (3.5%).

Coarse aggregate for concrete shall be free of coatings that will inhibit bond and injurious quantities of loam, alkali, organic matter, thin or laminated pieces, chert or other deleterious substances.

Coarse aggregate for concrete shall not have a soundness loss greater than eight percent (8%) by weight at the completion of sixteen (16) cycles of alternate freezing and thawing.

The percentage of wear by the Los Angeles Abrasion test shall not exceed forty percent (40%).

11.01 MATERIALS (Continued)

B. AGGREGATE (Continued)

TABLE 11.01

GRADATION LIMITS FOR MINERAL AGGREGATES FOR USE IN PORTLAND CEMENT CONCRETE				
TYPE OF MATERIAL	FINE AGGREGATE		COARSE AGGREGATE	
USED IN CONCRETE CLASS:	SG3000, L3500, L4500, L5500, LB2750, LC3500, PR		L3500, L4500, L5500 LB2750, LC3500, PR	
TOTAL PERCENT PASSING SIEVE	Target	Tolerance	Target	Tolerance
1 ½"	--	--	100	None
1"	100	None	100	-8
3/4"			78	±12
½"			--	--
3/8"			30	±15
# 4	87	±10	6	±6
# 10	60	±10	--	--
# 20	--	--	3	±3
# 30	28	±12		
# 50				
# 100				
# 200	1.5	±1.5		

11.01 MATERIALS (Continued)

C. WATER

Water for concrete or mortar shall be clean and free from injurious amounts of oil, acid, alkali, salt, organic matter, and other deleterious substances. Test specimens of mortar made from the materials and water to be used in the work shall develop a tensile or compressive strength at seven days of not less than ninety-five percent (95%) of that developed by the mixture of material and distilled water.

Wash-out water or water from the reclaiming process of Portland cement concrete shall not be allowed to be used in the mixture without permission from the Engineer.

D. CHEMICAL ADMIXTURES

All Chemical Admixtures shall conform to Section 1007, "Chemical Admixtures", of the latest addition of the Nebraska Department of Roads "Standard Specifications for Highway Construction".

Portland cement concrete shall be air-entrained. Air-entraining admixtures to be used with Portland Cement Concrete shall conform to ASTM Designation C 260, except that the strength of the concrete containing the admixture shall not be less than ninety-two percent (92%) of a similar concrete without the admixture at all test ages. The air-entraining characteristics of the admixture, when combined in suitable proportions with Portland Cement, aggregate, and water, within the limits of the proportions specified, shall be such that the resulting concrete will have a satisfactory work-ability and a total air content within the limits, as specified herein, for the different classes of concrete.

If the air content of the concrete at the job site is less than the minimum specified, only one addition of air-entraining admixtures to a load is allowed. If the air content is then outside the limits specified, the load of concrete shall be rejected.

Admixtures which are not incorporated into the mix at the plant shall not be added to individual loads of concrete at the job site to enhance work-ability or pump-ability without permission from the Engineer.

Admixtures shall not be added to individual loads of concrete at the job site to reduce either air content or slump without permission from the Engineer.

E. FLY ASH AND NATURAL POZZOLAN MODIFIED PORTLAND CEMENT CONCRETE

Portland Cement Concrete mixes for pavement, driveways, curb, median, and sidewalk may be modified by replacing a maximum of ten percent (10%) of the cement per cubic yard of concrete, as shown in Table 11.02, with an amount of Class F fly ash equal to two (2) times the weight of cement removed or by the use of Type IPN, cement made with 15 to 25 percent natural pozzolan, or by the use of Type IPF, cement made with 15 to 25 percent Class F fly ash, in the amount shown in Table 11.02. No additional fly ash substitution will be allowed to mixes utilizing Type IPN or Type IPF cement.

E. FLY ASH AND NATURAL POZZOLAN MODIFIED PORTLAND CEMENT CONCRETE (Continued)

An NDOR approved water-reducing admixture shall be used in all fly ash and natural pozzolan modified concrete mixes at the dosage rate recommended by the manufacturer. The water-cement ratio of all fly ash and natural pozzolan modified concrete shall not exceed the maximum limit for the various classes of concrete as shown in Table 11.02.

Fly ash shall conform to the requirements of Class F pozzolan of ASTM Designation C 618, except that the maximum loss on ignition for Class F pozzolan shall be six percent (6.0%). Additionally, Class F pozzolans shall have a maximum allowable free carbon content not to exceed three percent (3.0%). Class F fly ash shall not contain more than one and five-tenths percent (1.50%) of available alkalies as Na_2O. Fly ash such as is produced in furnace operations utilizing liming materials or soda ash (sodium carbonate) as an additive will not be acceptable. Certified mill tests shall be provided to the Engineer.

Only brands of Class F Fly Ash, Type IPN Cement, and Type IPF Cement which are on the latest edition of the Nebraska Department of Roads Approved Products List shall be approved for use in concrete in City of Lincoln projects.

The fly ash shall be protected from damage due to moisture. Fly ash so damaged shall be rejected. Fly ash shall not be in storage longer than ninety (90) days without retesting.

Cement and fly ash may be weighed in the same weigh hopper. However, the cement shall be weighed completely before the fly ash enters the weigh hopper.

Fly ash, Type IPN cement, and Type IPF cement shall not be used in mix designations LB2750, L4500, L5500 and PR without permission from the Engineer.

Fly Ash and Natural Pozzolan Modified concrete will not be allowed in structures without permission from the Engineer.

Fly ash and Natural Pozzolan Modified concrete shall not be used after October 1st or before April 1st without permission of the Engineer.

11.02 PROPORTIONS OF MIXTURES

All Portland Cement Concrete mixtures shall be composed of a mixture of Portland Cement, water, mineral aggregates, and air-entrainment as specified; according to Table 11.02.

The proportions within the limits given shall be determined by the Engineer and shall not be varied by the Contractor.

TABLE 11.02 - PORTLAND CEMENT CONCRETE MIXTURES

CLASS OF CONCRETE	LB-2750		SG-3000		L-3500		LC-3500		L-4500		L-5500		PR	
NOTES (See Below)	(3), (5)		(1), (5)		(3), (5)				(3), (5)		(3), (5)		(2), (3), (4), (5)	
General Use	Pavement Base		Misc. (Where Specified)		Pavement, Sidewalk & Structures		Curb		Bridge Deck & High Strength		Pavement High Strength		Pavement Repair (H.E.)	
Min. 28 Day Strength, psi (MPa)	2750 (19)		3000 (20)		3500 (25)		3500 (25)		4500 (31)		4500 (31)		4500 (31)	
Lbs. of Cement / cubic yard (kg/m^3)	423 (251)		564 (335)		564 (335)		564 (335)		658 (390)		752 (446)		799 (474)	
Aggregate Composition % by Weight	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
Fine Aggregate	58%	62%	100%	-----	67%	73%	67%	73%	67%	73%	67%	73%	67%	73%
Coarse Aggregate	38%	42%	-----	-----	27%	33%	27%	33%	27%	33%	27%	33%	27%	33%
Air Content	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
% of Volume	4.5	6.5	5.0	7.5	5.0	7.5	5.0	7.5	5.0	7.5	4.0	7.0	4.0	7.0
Maximum Water Cement Ratio	0.64		0.53		0.53		0.50		0.44		0.40		0.45	
Maximum Slump, inches (mm)	4.0 (102)		4.0 (102)		4.0 (102)		3.0 (76)		4.0 (102)		3.0 (76)		3.0 (76)	

NOTES:
(1) L3500 shall be used on all sidewalk constructed on City Contracts unless otherwise specified.
(2) Type III Cement
(3) No fly ash or natural pozzolan modified concrete allowed in pavement base, bridge, structures, high strength, or pavement repair mixtures without permission from the Engineer.
(4) Calcium Chloride may be added as per NDOR Standard Specifications for Highway Construction.
(5) The maximum slump may be exceeded by use of water reducer, high range water reducer, or both.
This table is for proportion ranges only. Actual mix design weights for specific applications will be provided by the City of Lincoln Materials Testing Laboratory.

11.03 HANDLING MATERIALS

The concrete constituents, when delivered to the mixing equipment, shall meet the requirements of the above Specifications.

The moisture content of the aggregate shall be reasonably uniform from batch to batch. Limestone having a moisture absorption of more than one percent (1%) shall be uniformly saturated with water before it is used. The saturation shall be performed sufficiently in advance of mixing operations to permit filling of the pores of the aggregate.

11.04 WEIGHING & MIXING

The constituents of the concrete shall be weighed or measured separately at a central batch plant. The central batch plant shall be in substantial compliance with the requirements in the Quality Control Manual, Section 3, Certification of Ready Mixed Concrete Production Facilities published by the National Ready Mixed Concrete Association. The Contractor shall be responsible for the calibration of the plant on an annual basis or as deemed necessary by the Engineer.

The concrete batch shall be either plant-mixed by the central batch plant or truck-mixed using transit mixing trucks. Mixing time and rate requirements shall be based on the size of batch and the mixing drum manufacturers specifications. Mixing time shall start when the cement and water are combined. The concrete shall be transported to the job site in clean, water-tight trucks. A load ticket showing the date, time, plant designation, mix designation, batch size, material quantities per batch, and aggregate moisture values used to calculate aggregate quantities shall accompany each load and be made available to the Engineer.

No concrete shall be used from a batch that has exceeded ninety (90) minutes from the start of mixing time. A lesser time may be specified by the Engineer if, in his opinion, conditions warrant it. Concrete hauled in non-agitating trucks shall be placed within thirty (30) minutes after mixing time starts.

The temperature of the concrete shall be between 50°F and 95°F when delivered to the work. The temperature of the combined aggregate and water shall not exceed 95°F.

11.05 CONSISTENCY AND PLACEMENT OF CONCRETE

In general, the minimum amount of water shall be used which will produce the required work-ability. The mortar shall cling to the coarse aggregate and shall show no free water when removed from the mixer. The upper surface of the set concrete shall show a cement film upon the surface, but shall be free from laitance. In no case shall so much water be used so as to cause the collection of surplus water on the surface, or to cause segregation of the materials during transportation or placing of the concrete.

Concrete shall be plastic, cohesive and workable, and uniform from load to load. Workable concrete is defined as a concrete which can be placed without honeycomb and without surface voids. Work-ability shall be obtained without producing a condition such that free water appears on the surface when finished. The consistency of the mixture shall be that required for the specific conditions and methods of placement; however, the maximum water cement ratio, as specified in Table 11.02, shall not be exceeded.

The maximum allowable interval for placing successive concrete loads on grade for paving or into forms and excavations for structures shall be 30 minutes unless directed otherwise by the Engineer. Concrete free fall distance shall not exceed 5 feet. This includes free fall in a discharge pipe when using a conveyor system for placement. Pumped concrete is not considered in free fall until the concrete exits the pumper hose.

11.06 CONCRETE TESTS

The Engineer shall take such tests of the concrete as he deems necessary to determine the strength and the air, water, cement and aggregate proportions. The properties of the concrete will be determined by the tests specified in ASTM Designation C 94.

11.07 FLOWABLE FILL

A. DESCRIPTION

Flowable Fill shall be a mixture of cement, fly ash, fine sand, water, and air having a consistency which will flow under a very low head.

B. MATERIALS

The approximate quantities of each component per cubic yard of mixed material shall be as shown in Table 11.03.

Table 11.03 Flowable Fill Composition per cubic yard

Cement (Type I or II)	60 pounds
Fly Ash	200 pounds
Fine Sand (ssd)	2,700 pounds
Water (approx.)	420 pounds
Air Content (approx.)	10%

Actual quantities shall be adjusted to provide a yield of 1 cubic yard with the materials used.

Approximate compressive strength should be 85 to 175 psi.

Fine Sand shall be an evenly graded material having not less than 95 percent passing the No. 4 sieve and not more than 5 percent passing the No. 200 sieve.

Handling and mixing of the materials shall be in accordance with sections 11.03 and 11.04 above.

Cement must be on the latest NDOR Approved Products List.